

March 14, 1961

N. H. BROWN

2,975,419

MICROWAVE ANTENNA REFLECTOR SYSTEM FOR SCANNING
BY DISPLACEMENT OF FOCAL IMAGE
Filed Oct. 13, 1959

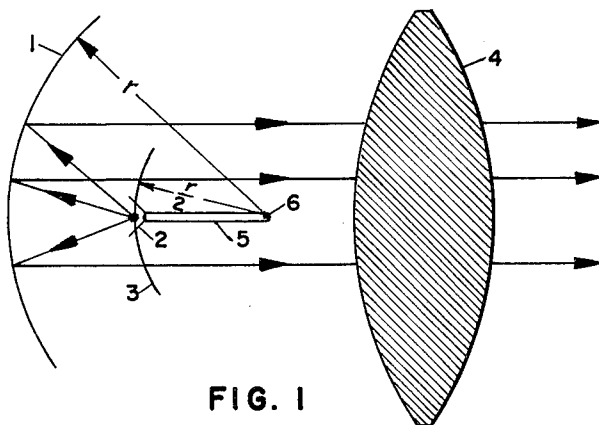


FIG. 1

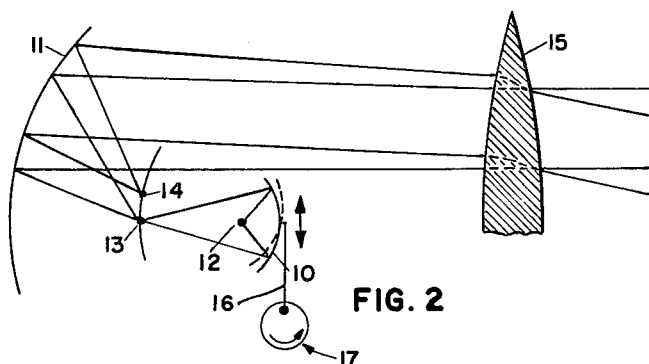


FIG. 2

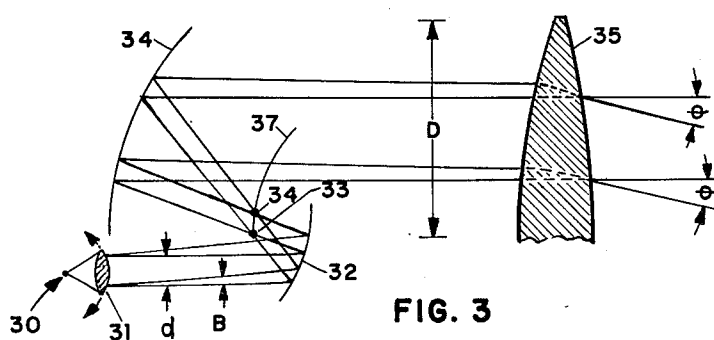


FIG. 3

INVENTOR.
N. H. BROWN
BY *McShrago*
ATTORNEY

1

2,975,419

MICROWAVE ANTENNA REFLECTOR SYSTEM FOR SCANNING BY DISPLACEMENT OF FOCAL IMAGE

Newell H. Brown, Morristown, N.J., assignor, by mesne assignments, to the United States of America as represented by the Secretary of the Navy

Filed Oct. 13, 1959, Ser. No. 846,219

5 Claims. (Cl. 343—754)

The present invention relates generally to directive antenna systems and more particularly to wide angle scanning microwave antennas.

Most of the wide angle scanning microwave antenna systems suitable for hemispherical search radar require the movement of relatively large structures, such as, for example, the antenna reflector and its feed assembly, to accomplish the desired scanning. The microwave analog of the Schmidt optical system which has been found to be suitable for such applications as the one just mentioned consists, as is well known, of a spherical reflector and a refractive lens for correcting spherical aberrations. The focal line of this system is a circular arc concentric with the spherical reflector of radius

$$\frac{r}{2}$$

r being the radius of the spherical reflector. Scanning is accomplished by simply moving the microwave source along this circular arc. The conventional way of producing this movement is to rotate a feed structure having a radial length of

$$\frac{r}{2}$$

about the center of curvature of the spherical reflector. This method, it would be seen, also imposes severe requirements on the mechanical design of the scanner, especially where the geometry of the system is large and the scanning is being done at a relatively rapid rate. Furthermore, the conventional Schmidt system suffers from aperture blocking because of the interference of the feed structure and its drive mechanism with the reflected microwave beam.

It is therefore a primary object of the present invention to provide an improved scanning arrangement for a wide angle microwave antenna system.

Another object of the present invention is to provide an arrangement for accomplishing wide angle scanning of a microwave beam wherein the structural demands imposed on the mechanical components of the system are minimized.

A still further object of the present invention is to provide an improved microwave analog of the Schmidt optical system for use in wide angle scanning radar systems.

A still further object of the present invention is to provide a wide angle scanning arrangement capable of operating at relatively fast scanning rates.

A still further object of the present invention is to provide a microwave analog of the Schmidt optical system which does not suffer from aperture blocking.

A still further object of the present invention is to provide a mechanically controlled wide angle scanning antenna wherein the scanning motion is effectively amplified within the system.

A still further object of the present invention is to provide a microwave antenna system which achieves wide

2

angle beam scanning with only relatively small mechanical movement of its control apparatus.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a schematic illustration of a conventional microwave analog of the Schmidt system;

Fig. 2 is a modification of the Schmidt system of Fig. 1 wherein the spherical reflector is illuminated by an image source positioned at its focal line; and

Fig. 3 is a further modification of the Schmidt system employing a folded virtual source for illuminating the spherical reflector so as to achieve scanning multiplication.

Briefly and in general terms, the above objects are realized according to the present invention by displacing an image of the microwave source, rather than the source itself, along the focal line of the spherical reflector of the conventional Schmidt system. In one case, this image is formed by an ellipsoidal reflector located at the center of curvature of the spherical reflector and dimensioned such that one of its foci occurs at the focal line of said spherical reflector. Thus, when a microwave point source is positioned at its other focus, an image thereof is formed at the desired location. In another case, energy from a point source is collimated by a microwave lens and the resultant beam directed upon a stationary reflecting surface which generates an image of the point source at the focal line of the spherical mirror. Scanning is realized in the first arrangement by simply oscillating the ellipsoidal reflector, while in the second arrangement this result is achieved by simply moving the point source and the collimating lens. In both arrangements the mechanical movement required is very small, but only in the embodiment using the stationary reflecting surface is the objectionable effect of aperture blocking limiting since, as will be seen hereinafter, the position of the stationary reflector is not within the path of the reflected microwave beam.

Referring now to Fig. 1 there is shown a conventional microwave analog of the Schmidt system consisting of, as mentioned hereinbefore, a spherical reflector 1 illuminated by a microwave point source, such as horn 2, located at its focal line 3. This line is a circular arc of radius

$$\frac{r}{2}$$

r being the radius of the spherical reflector. The microwave energy radiated from source 2 strikes the spherical reflector and is reflected therefrom as a substantially parallel beam. In order to correct for the spherical aberration present, a refractive lens 4 is placed in the path of the beam prior to its radiation into free space. For beam scanning purposes, it is only necessary that point source 2 be moved along focal line 3. This movement is usually accomplished by rotating the feed structure 5 for horn 2 about the center of curvature 6 of reflector 1. The length of the feed structure must, of course, be

$$\frac{r}{2}$$

to reproduce this movement. Some of the shortcomings of this system are the structural demands made on the mechanical apparatus rotating the feed assembly 5 and source 2 and the interference of these assemblies with the reflected microwave beam.

The extent of mechanical movement necessary to ac-

3

comply a given amount of beam scanning with the Schmidt system can be reduced appreciably by means of the modification shown in Fig. 2. Here, an ellipsoidal reflector 10 is positioned at the center of curvature of spherical reflector 11, and a microwave source 12 is located at one of its foci. The dimensions of ellipsoidal reflector 10 are such that its other focus 13 occurs at a point somewhere along the focal line 14 of spherical reflector 11. It will thus be seen that the image of microwave source 12 generated at focus 13 may be displaced along the focal line to point 14, for example, by oscillating ellipsoidal reflector 10. This arrangement reduces the extent of mechanical movement necessary to accomplish a given amount of beam scanning since the mechanical components are concentrated at the center of curvature of the spherical reflector, and the magnifying effect of the moment arm correspond to the radial distance between the center of curvature and the focal line is removed. Although this modification does simplify the mechanical design problems, it does not, however, completely eliminate aperture blocking since reflector 10 must be at the center of curvature 6 and, hence, perforce interfere to some extent with the reflected microwave beam. Any conventional mechanism can be employed to oscillate reflector 10, such as, for example, a rotating eccentric 17 driving a crank arm 16 connected at its other end to the reflector.

Fig. 3 illustrates a preferred modification of the invention wherein the spherical reflector is illuminated by means of a folded image source. In this system microwave energy from a point source 30 is collimated by lens 31 and directed upon a stationary reflecting surface 32 which generates a new image source 33 substantially at the focal line 37 of the spherical mirror 34 of a conventional Schmidt system. Scanning is achieved by simply moving point source 30 and collimating lens 31. Here, the mechanical movement required is very small and no significant aperture blocking results since all the components including reflector 32 are well removed from the path of the reflected microwave beam.

It would be pointed out in connection with this system that aberration may result from the optics of the spherical reflector 34, the optics of the reflecting surface 32 and the shift of illumination with the movement of source 30 and lens 31. These aberrations can be corrected by lens 35 so that the change in antenna performance is minimized during the scanning operation.

In selecting the characteristics of the stationary reflector 32, the following factors should be considered. The focal line of this reflector should approximate the focal line of the spherical reflector, reflections from this component should be capable of being focused by a simple lens system to point 30 and the aberrations should be corrected by either lens 31 or 35 to an extent such that antenna performance is not seriously degraded by the scanning action. The details of the reflecting surface defined by these requirements can be determined by a combined analytical-empirical program. In one embodiment of this system, lens 30 and point source 31 consist of a conical electromagnetic horn and correcting lens with the scanning obtained via mechanical oscillation of the horn. Alternatively, a parabolic reflector and feed assembly with either of these components oscillating may be utilized.

It is of interest to note that not only does the above modification result in small mechanical motion without aperture blocking but that, in addition, the scan motion is effectively amplified. With reference to Fig. 3, it will be seen that this arrangement in reality is a combination of two optical systems: namely, a Schmidt system of large aperture D scanned through an angle θ when the image source moves, for example, from point 33 along the focal line of spherical reflector 34 to point 36 combined by the stationary reflector 32 with a lens and parabolic reflector system of a smaller aperture d scanned through an angle

4

β to reproduce this image movement. By proper choice of the geometry of the two systems,

$$\frac{D}{d}$$

may easily reach values of twenty or greater and

$$\frac{\theta}{\beta}$$

may exceed unity. Thus, for example, if

$$\frac{D}{d}$$

equals twenty and

$$\frac{\theta}{\beta}$$

equals one and if β equals two half power beam widths of aperture d , then θ equals forty beam widths of aperture d . Since θ is the half scan angle, a total scan of eighty beam widths is achieved for a scan motion of four beam widths in the small aperture system. It will thus be seen that the original objective is accomplished of scanning with small motion, amplifying this scan motion and applying the amplified scan motion to a large aperture system.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A wide angle microwave scanning arrangement comprising, in combination, a spherical reflector, an ellipsoidal reflector positioned at the center of curvature of said spherical reflector, a microwave source located at one focus of said ellipsoidal reflector, the dimensions of said ellipsoidal reflector being such that the other focus of said ellipsoidal reflector occurs at a point along the focal line of said spherical reflector whereby an image of said microwave source is generated at said other focus and means for oscillating said ellipsoidal reflector.

2. A modified Schmidt wide angle scanning system comprising, in combination, a spherical reflector, a point source of microwave energy, means for generating an image of said source at the focal line of said spherical reflector and means for cyclically displacing said image along said focal line thereby to cause scanning of the beam of microwave energy reflected from said spherical reflector.

3. A wide angle microwave scanning system comprising, in combination, a spherical reflector, a point source of microwave energy, means for forming an image of said point source at the focal line of said spherical reflector and means for displacing said image along said focal line thereby to cause scanning of the beam reflected from said spherical reflector.

4. A modified microwave analog of the Schmidt optical system comprising, in combination, a spherical reflector, an ellipsoidal reflector symmetrically disposed about the center of curvature of said spherical reflector with one focus of said ellipsoidal reflector occurring somewhere along the focal line of said spherical reflector, a source of microwave energy at the other focus whereby an image of said source is formed at said focal line, means for oscillating said ellipsoidal reflector thereby to cause scanning of the beam reflected from said spherical reflector and a dielectric lens positioned in the path of said reflected beam to correct for spherical aberration resulting from the characteristics of said spherical reflector.

5. A microwave scanning arrangement comprising, in combination, a spherical reflector, a point source of micro-

waves, means for producing an image of said microwave source at the focal line of said spherical reflector, and means for cyclically displacing said image along said focal line, thereby to cause the beam reflected from said spherical reflector to perform a scanning operation.

References Cited in the file of this patent**UNITED STATES PATENTS**

2,595,271	Kline	May 6, 1952
2,609,505	Pippard	Sept. 2, 1952